Exploring Color Maps

Visualizing the Ozone Hole

This lesson will introduce students to the use of color maps to visualize data about stratospheric ozone. Scientists use colors and other representations for data to help interpret and visualize information. Data are mapped to colors and other representations to help the mind interpret this information. Sometimes this means creating an image that looks much like an aerial photo of the planet's surface, but other data are best mapped to a color scale. Students will create their own color map and discover that selecting a good color scale is both essential to understanding data and to accurately communicating science.

Objectives

After completing this activity, students should be able to

- describe why color maps are used to visualize data
- interpret data using a color mapped image
- compare and evaluate different color scales

Standards (Grades 9-12)

NGSS: Practice 4 Analyzing and Interpreting Data

AAAS: 12E/H2 Check graphs to see that they do not misrepresent results by using inappropriate scales.

AAAS: 11C/H4 Graphs and equations are useful ways for depicting and analyzing patterns of change.

NSES: Unifying Concepts and Processes Standard: Evidence, models, and explanation.

NSES: Content Standard E: Understandings about science and technology

Materials

- Images on the Ozone Hole poster
  http://aura.gsfc.nasa.gov/ozoneholeposter/
- Color by Number Worksheet
- 7 colored pencils / crayons
- Sea Surface Temperature maps (in color)

Engage

Ask questions about the front of the poster. When was the ozone hole the smallest? (1979) When did the ozone hole grow the fastest? (1981–1985, pattern of growth, no shrinking) What year had the largest ozone hole? (2006) Ask students to provide evidence for their answers. (the graph, the globes, the colors) Ask what helped answer the questions.

Explore

Using the "Color by Number" worksheet, ask students to create a visual representation that accurately communicates the size of the ozone hole. Invite students to make up their own color scale. The seven ranges of ozone data may be divided any way they like. Ranges don't have to start at zero and don't have to be even units. They can choose any colors or shades of colors they like. (If the activity is being done by an individual student, color two maps with different scales.) Encourage students to think about the range and why they choose it.

Post the back of the poster so students can gather more information about the ozone hole to help them design their color scales. You can also post some ozone facts on the board.

Ozone facts: The average ozone levels over the entire globe is 300 Dobson Units. Values lower than 220 Dobson Units are considered part of the ozone hole. In 2006, the worst year for ozone depletion to date, the lowest values of 84 Dobson Units were observed.

Explain

Post student color maps on the wall and compare. Do any look like there is almost no hole? Which one is easiest to understand? Why? Hardest to understand? Why? Why not use the same color for all types of data? Explain how the different color scales help us to visualize data by drawing attention to what is important, such as the location of the ozone hole. However, color can also be deceptive, such as when there is a break in a color scale that stands out where there is nothing really unique about the data.

For more information, visit:

http://aura.gsfc.nasa.gov/ozoneholeposter/
http://ozonewatch.gsfc.nasa.gov
http://earthobservatory.nasa.gov

Evaluate

Looking back at the poster, ask students "Why was this particular color scale chosen?" (There is a noticeable break from light to dark blue at 220 DU, where values lower than 220 DU are considered to be the "ozone hole.") Ask students to think about their scales and describe why they chose certain colors and data ranges. Which data were emphasized or de-emphasized in their color maps?

Extension - Comparing Color Scales

As we have seen, a data set like ozone is best represented as a range of colors. However, color scales are arbitrary and can be chosen according to how the data can best be visualized. Hand out, or project on the screen, the Sea Surface Temperature maps. Ask students to compare the 4 different color scales. These maps show the exact same data (September 2011) but use different color scales and ranges.

This activity could be conducted as a written assessment, or journaling activity, or as a class discussion. For small groups, ask students discuss the questions and record their answers as a group. Then invite the groups to share their answers with the class.

Comparison 1 - Maps A and B:

Q1: Does one map show hotter sea surface temperatures than the other? (Neither. Both maps are the same data. Map A appears to be hotter because of the amount of red used in the color scale.)

Q2: Compare and contrast the two scales? (Both maps use the rainbow colors as their color scale. Map B has a wider green area and less red. Map B shows more detail in the Gulf of Mexico.)

Comparison 2 - Maps A and C:

Q1: Are there any features that stand out in one and not the other? (In Map A, there appears to be a feature flowing east from the north eastern United States. This appears to be significant because the color scale shows strong breaks between red, yellow and green. However, there is not a significant change in the temperature data as the map suggests.)

Q2: Which one do you think a color blind person could interpret? (Map C because this map can also be interpreted if printed in black and white. Additionally some people who have a difficulty distinguishing between green and blue would have a hard time interpreting the rainbow scale.

Comparison 3 - Maps C and D:

Q1: Which map do you think more accurately represents changes in temperature? (Map C is the most accurate representation of the data because each change in color value on the scale maps evenly to changes in the data—degree of temperature change.)

Q2: Why do you think the color scale in Map D is so different? (The scale for Map D has a break in the color from blue, to yellow, to orange around 27.8°C— the temperature that will sustain a hurricane. Thus, this color scale is purposely adjusted to emphasize sea surface temperatures that will sustain a hurricane.)

Comparison 1 - Maps A and B:

Q1: Does one map show hotter sea surface temperatures than the other?

Q2: Compare and contrast the two scales?

Comparison 2 - Maps A and C:

Q1: Are there any features that stand out in one and not the other?

Q2: Which one do you think a color blind person could interpret?

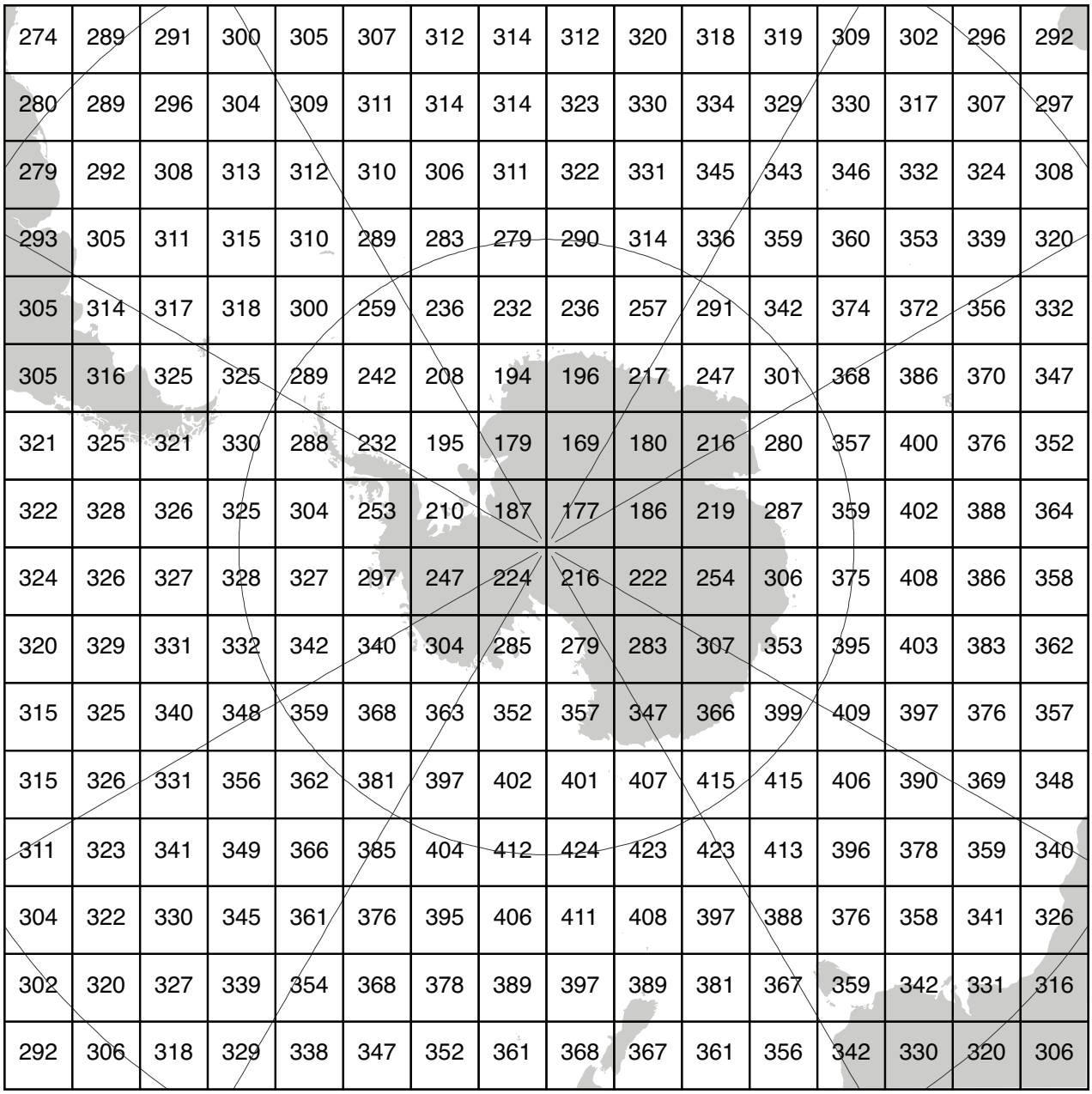
Comparison 3 - Maps C and D:

Q1: Which image do you think more accurately represents changes in temperature?

Q2: Why do you think the color scale in Map D is so different?

Color by Number Worksheet

NASA's fleet of Earth observing satellites produce 1500 Terabytes of data each year, enough to fill 3000 laptops, each with a 500 GB hard drive. To help interpret this wealth of data, scientists rely on techniques to visualize information such as mapping data values to colors. Create your own color map using data from Aura's OMI instrument.



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305	314	317	318	300	259	236	232	236	257	291	342	374	372	356	332
305	316	325	325	289	242	208	194	196	217	247	301	368	386	370	347
321	325	321	330	288	232	195	179	169	180	216	280	357	400	376	352
322	328	326	325	304	253	210	187	177	186	219	287	359	402	388	364
324	326	327	328	327	297	247	224	216	222	254	306	375	408	386	358
320	329	331	332	342	340	304	285	279	283	307	353	395	403	383	362
315	325	340	348	359	368	363	352	357	347	366	399	409	397	376	357
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311	323	341	349	366	385	404	412	424	423	423	413	396	378	359	340
304	322	330	345	361	376	395	406	411	408	397	388	376	358	341	326
302	320	327	339	354	368	378	389	397	389	381	367	359	342	331	316
292	306	318	329	338	347	352	361	368	367	361	356	342	330	320	306

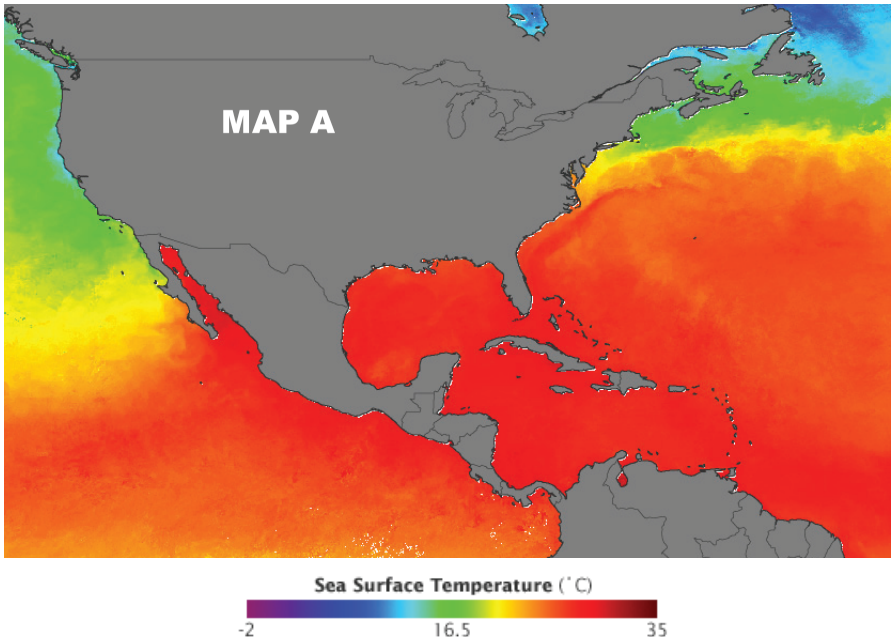
October 2012 Total ozone Color Scale (Dobson Units)

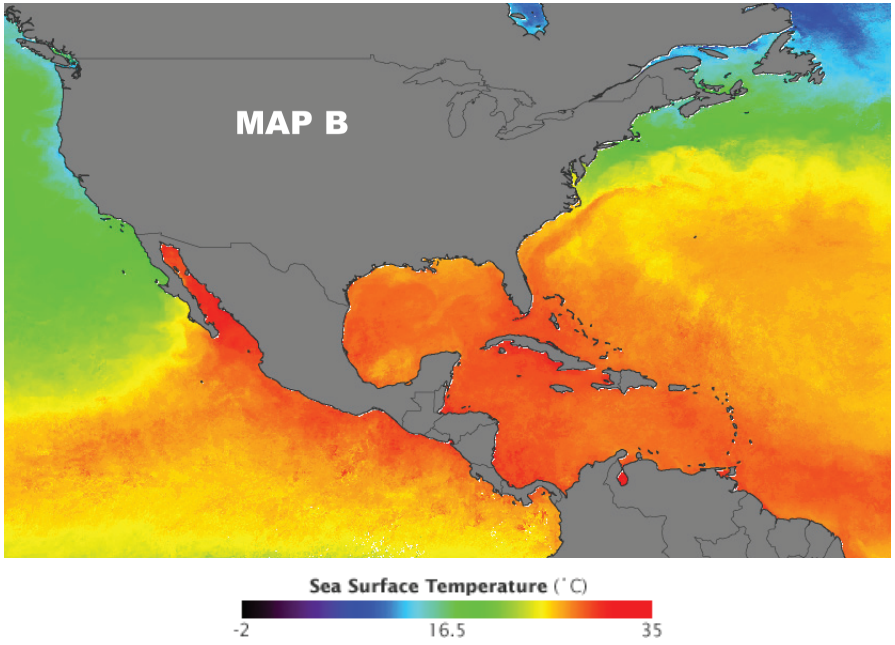
_____	_____	_____	_____	_____	_____	_____

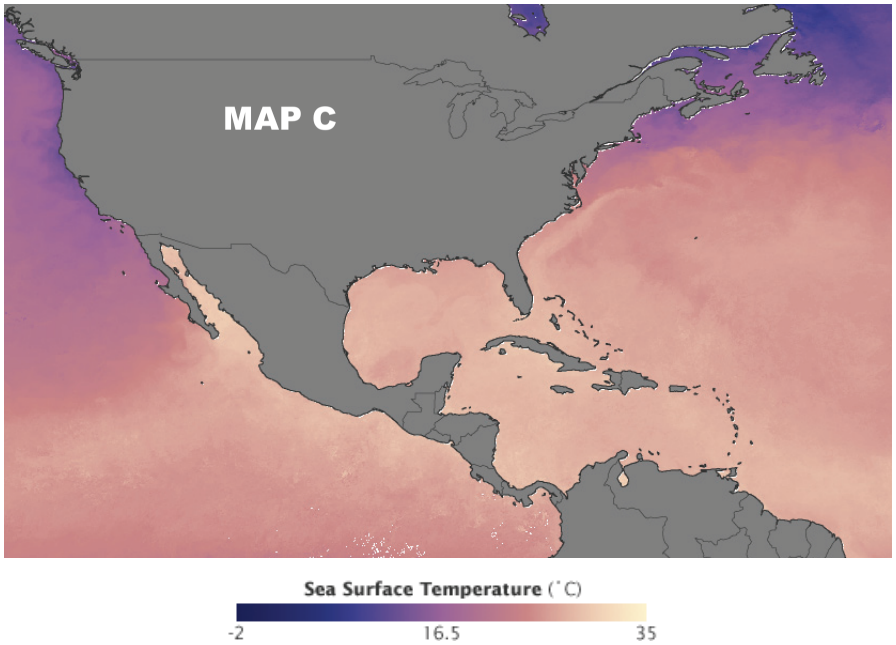
Directions: Create your own color map. Color in the color scale with any colors or shades of colors you choose. Label the data ranges for each color. Ranges do not have to start at zero or be segmented evenly. Your challenge is to create a color scale that will accurately represent the size of the ozone hole.

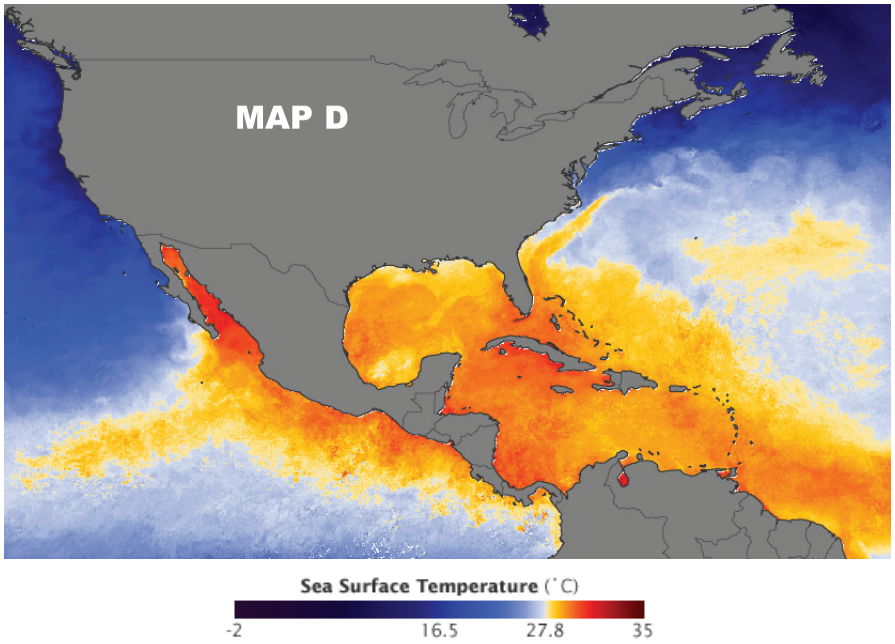
Sea Surface Temperatures

from September 2011 using 4 different color scales









NP-2013-3-014-GSFC